U. S. DEPARTMENT OF COMMERCE

BUILDING MATERIALS AND STRUCTURES

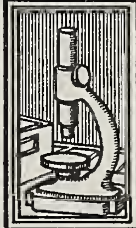
REPORT BMS35

Stability of Sheathing Papers as Determined by Accelerated Aging

by

SAMUEL G. WEISSBERG
DANIEL A. JESSUP, *and*
CHARLES G. WEBER

NATIONAL BUREAU OF STANDARDS



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Foreword

Sheathing paper constitutes a relatively small part of the total cost of a house. However, the importance of the paper as a component part of the structure may be many times greater than its cost would indicate. It is used as a barrier against the infiltration of water and air from the outside, and against loss of moisture vapor from within. Papers that will perform these functions satisfactorily while new are readily available, but heretofore no data were available on the stability of these products. This report presents the results of tests to determine the relative lasting qualities of some of the more common types of commercial sheathing papers.

Lyman J. Briggs, *Director.*

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ABSTRACT

The more familiar types of sheathing papers were tested to obtain authoritative information on how well they can be expected to retain their desirable qualities in service. Accelerated aging was used, because to obtain comparable data from natural aging would require much more time. The aging treatment included cycles of wetting, freezing, drying, and baking; and the effects of the treatment were observed by comparison of the properties before and after aging. Important properties of this class of papers are resistance to the passage of air, water, and water vapor; hence, the judgment of stability was based largely on the degree of retention of those attributes. In general, the papers lined with metal foils were least affected by aging. The asphalt-treated papers differed widely. The single-ply papers as a class had lower initial resistance to water and moisture vapor than the laminated papers but retained the resistance somewhat better than the latter, although one of the duplex papers received a very high rating. Rosin-sized papers had unsatisfactory aging properties.

I. INTRODUCTION

Sheathing papers have an important place in most house building. Originally used in frame construction as a protection against the infiltration of air and the passage of water through walls, they now have additional protective functions. They serve as barriers against the infiltration of water and water vapor in practically all types of construction, including frame, stucco, and brick veneer. Also, with the advent of air conditioning, and with the increasing use of fill insulation, sheathing paper has become very important as a seal against the passage of moisture vapor from within the structure, which may result in sufficient condensation within the walls during the winter months to cause serious damage to the structure.

Studies of some of the properties of sheathing papers have been made by Carson,[1] and a Federal specification [2] contains well-established values for strength and water resistance. More recently, studies of the problem of condensation of moisture within walls have included tests of the relative efficiency of various sheathing papers as moisture seals. Results of these tests have been published by investigators [3] at the Forest Products Laboratory at Madison, Wis.

From the information already available, it appears that sheathing papers are made to meet all ordinary requirements for strength and resistance to permeation by water, water vapor, and air. It is, therefore, not difficult to obtain a paper which will perform a specific function within a wall initially. Heretofore there has been no information available relative to the stability of such papers. It was the purpose of this investigation to obtain data on how long the papers can be expected to perform the functions for which they are selected. The most satisfactory method of predicting their service life would be to base an estimate on field observations after years of service. However, as such data are not available, and because of the

[1] BS J. Research 3, 75 (1929) RP85.

[2] Federal Specification UU-P-536, Paper; Sheathing, Waterproof.

[3] Heinig, Teesdale, and Curran, Comparative resistance to vapor transmission. Presented at 1939 Annual Meeting, Tech. Assn. Pulp & Paper Ind., N. Y.

impracticability of waiting years for them, accelerated aging was employed. This method produces, in a relatively short time, effects similar to those arising from long periods of natural aging. The conditions used are qualitatively similar to those encountered in service, but are made much more drastic in order to produce results quickly. Experience at the Bureau with record papers [4] [5] and with roofing materials [6] and fiber building boards [7] has demonstrated the usefulness of accelerated aging for predicting the permanence of fibrous materials. It is believed that the procedure is applicable in this instance.

II. DESCRIPTION OF SAMPLES

The papers studied in this investigation were obtained from cooperating manufacturers. They were selected and obtained with the assistance of the National Lumber Manufacturers Association. Inclusion of all commercial brands was not deemed necessary, but effort was made to secure samples of current production that would be representative of all the types in common use in house construction. Twenty-one papers from seven manufacturers were tested. These may be divided into the following four groups, some of which comprise several types and weights.

1. Laminated Paper Products

The largest group was composed of nine laminated papers consisting of two or more plies of paper cemented together with asphalt. The asphalt, in addition to functioning as the adhesive, binding the plies together, acts as the principal moisture barrier. As further protection against moisture, some of the papers had one or more plies saturated with asphaltic material. With the exception of one three-ply paper, all of the laminated products were of two-ply construction. Four papers contained reinforcing cords between the plies to add strength.

2. Single-Ply, Asphalt-Treated

Six samples were papers impregnated with asphalt to render them resistant to moisture. The base papers in this group included medium-weight kraft, comparable to kraft wrapping paper, light-weight roofing felt, and paper made principally of asbestos fiber.

3. Metal-Foil Laminated Products

A third group consisted of laminated products made up of one layer of thin metal foil and one or more layers of kraft paper cemented together with asphalt, with or without reinforcing cords. This type of sheeting is a comparatively recent commercial development.

4. Rosin-Sized Paper

Only one paper that had not been treated after manufacture to enhance its resistance to moisture was included. It was a paper of the type known to the trade as "red rosin sheathing." This is simply a coarse paper of the general nature of heavy wrapping, sized with rosin for water resistance and pigmented dull red for identification.

III. DETERMINATION OF STABILITY BY ACCELERATED AGING

Sheathing paper as a component part of a building may be subjected to wide variations of temperature and humidity. The seasonal variations of temperature are often greater than 55° C, and the hygroscopic condition may vary from extreme dryness during hot weather to actual wetness from water infiltration. The accelerated-aging treatment which subjected the sheathing papers to an intensified simulation of normal weathering consisted of the following cycle: Oven drying at 65° C for 3 hours; immersion in water at room temperature for 3 hours; freezing at −12° C for 18 hours. This treatment was continued for a total of 600 hours, 25 cycles, and the effects measured.

The accelerated-aging treatment was designed to produce results similar to those arising from normal weathering and did not include all factors which may produce deterioration under limited or special circumstances. No attempt was made, for example, to determine the effect of lime from wet plaster or mortar on the papers. The destructive action of lime on aluminum is well known, and it is assumed that

[4] BS J. Research **7**, 466 (1931) RP352.
[5] BS J. Research **11**, 727 (1933) RP620.
[6] J Research NBS **18**, 669 (1937) RP1002.
[7] Building Materials and Structures (1938) NBS Rep. BMS4

the aluminum-laminated papers will not be used where they are subject to damage from this cause.

The effects of accelerated aging, which constitute the yardstick by which the stability of papers is measured, are obtained by observing the changes attributable to the treatment. The aging produced changes in permeability to water, water vapor, and air; in tensile strength; and in dimensions. The original properties of the papers and the changes in permeability and strength during aging are shown in table 1.

TABLE 1.—*Properties of sheathing papers and some changes produced by accelerated aging*

Papers: Laboratory designation	Papers: Type	Total weight	Weight of asphaltic component	Ash	Tensile breaking strength [a]: Machine direction	Tensile breaking strength [a]: Cross direction	Time of water penetration [b] through the paper	Permeability to water vapor [c]	Permeability to air [d]	Effects of accelerated aging [e]: Loss of tensile strength	Effects of accelerated aging [e]: Loss of water resistance	Effects of accelerated aging [e]: Increase in permeability to water vapor	Descriptive remarks
		lb/500 ft²	*lb/500 ft²*	*Per-cent*	*lb/in.*	*lb/in.*	*Hours*	*(g/m²)/24 hr*	*(cm³/m²)/sec / g/cm²*	*Per-cent*	*Per-cent*	*(g/m²)/24 hr*	
UU	3-ply asphalt-laminated, reinforced.	37	19	0.5	75	42	36	2.5	0.03	60	50	5.4	3 plies of kraft paper with reinforcing cords.
ST	2-ply asphalt-laminated, reinforced.	36	20	.6	89	53	18	1.8	.14	56	56	11.0	2 plies of kraft with reinforcing cords.
SU		30	15	.8	80	60	18	1.9	.08	46	83	12.5	2 plies of kraft, asphalt-saturated, with reinforcing cords.
VV		34	16	.7	77	45	24	3.6	.29	46	90	7.0	2 plies of kraft, with reinforcing cords.
ZZ	2-ply asphalt-laminated, not re-inforced.	17	7	.6	67	27	44	3.3	.02	23	93	0	2 plies of kraft.
WW		24	13	.8	46	34	36	1.9	.05	46	83	0.6	Do.
TT		41	22	.7	68	50	10	6.5	.14	9	70	0	2 plies of kraft, creped and asphalt-saturated.
ZZZ		28	15	.7	44	41	36	1.7	.10	19	86	3.3	2 plies of kraft, 1 ply plain, 1 ply creped and asphalt-saturated
Z		112	78	5.8	76	40	Impervious	0.5	.02	13	0	0	2 plies, 1 ply plain kraft on 1 ply of asphalt-saturated felt.
Y		34	4	6.6	37	12	1/60	126.0	87.00	20	100	44.1	2 plies of plain paper, asphalt-treated by "KB" process.
U	1-ply asphalt-impregnated.	82	48	5.1	47	24	8	8.5	7.30	0	0	0	Asphalt-saturated felt.
V		34	17	3.2	37	21	1	22.0	2.70	7	0	0	Asphalt-saturated felt, lightweight.
YY		15	7	0.7	47	29	1/2	8.8	2.50	16	83	23.8	Asphalt-saturated kraft.
T		55	24	4.3	94	32	21	1.6	0.08	10	0	2.3	Asphalt-saturated and coated felt.
X		79	25	55.3	47	14	8	8.0	1.30	0	37	2.2	Asphalt-saturated asbestos paper.
XX	Laminated, with metal foil.	21	3	(f)	70	38	Impervious	Impervious	Impervious	17	No change	No change	1 ply of aluminum foil and 1 ply of kraft.
Q_1		93	37	(f)	103	79				3			1 ply of copper foil (1 oz), 1 ply of kraft creped, and 1 ply of kraft plain.
Q_2		116	23	(f)	119	114				0			Same as Q_1, except with 2-oz copper foil.
R_2		109	21	(f)	102	90				13			1 ply of copper foil (2 oz), 1 ply of creped kraft with reinforcing cords.
R_3		131	22	(f)	220	216				3			Same as R_2, except with 3-oz copper foil.
W	Rosin-sized	33	0	16.0	39	27	1/60	198.0	140.00	31	100	3.7	Rosin-sized, not asphalt-treated.

[a] Tensile tests made on pendulum-type, power-driven machine. Specimens 1 in. wide; testing length, 3 in.

[b] Water penetration determined by dry indicator method. TAPPI Std. T433m, Tech. Assn. Pulp & Paper Ind., 122 E. 42d St., New York, N. Y.

[c] Method for moisture vapor permeability proposed by Subcommittee, Tech. Assn. Pulp & Paper Ind., Brabender, Paper Trade J. **108**, No 4 (Jan. 1939).

[d] Air permeability determined with Carson precision permeability tester. BS J. Research **12**, 567 (1934) RP681.

[e] Accelerated aging consisting of 600 hr of cyclic treatment. Each cycle=oven-drying at 65° C, 3 hr; immersion in water, 3 hr; freezing at −12° C, 18 hr.

[f] Foil papers were not ashed.

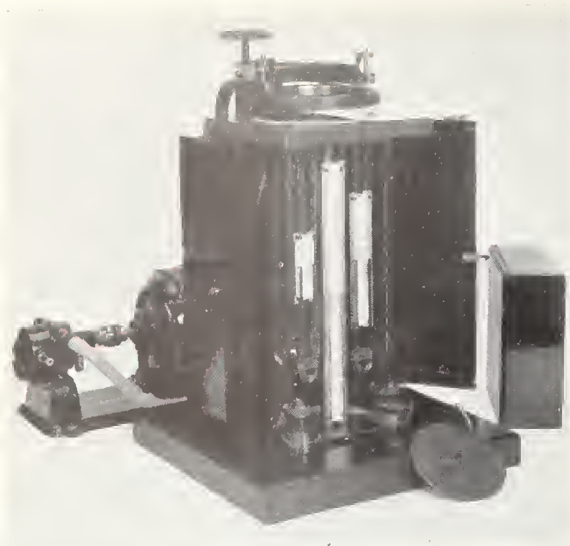

FIGURE 1.—*Precision instrument for measuring the air permeability of papers.*

1. PERMEABILITY TO AIR, WATER, AND WATER VAPOR

One of the important functions of sheathing paper is to prevent infiltration of air as a result of wind pressure. All papers tested had comparatively low permeability, apparently so low that the infiltration through any of them, if they are properly installed, would be an insignificant factor in the loss of heat from the structure. Accelerated aging changed the permeability in some instances, but the changes were relatively small, and the papers apparently retained sufficient resistance that their utility in this respect was not impaired to any appreciable degree. Measurements of air permeability were made with the precision permeability instrument developed by Carson.[8] The apparatus is shown in figure 1.

In view of the importance of its function as a barrier against the infiltration of water, the necessity for sheathing paper to retain its resistance to water is apparent. Wet walls are no more welcome in a house that has been erected for 10 years than in a new one.

The papers varied quite widely as regards both the initial permeability to water and the retention of water resistance after accelerated aging. As a class, the metal-foil laminated papers were the most satisfactory in both respects. They were all impervious, as determined by the available methods, and remained so after aging. These papers are, however, much more expensive than the other types and are not strictly comparable for that reason.

The two- and three-ply papers had good initial water resistance; but, with one exception, these papers lost 70 percent or more of their resistance under accelerated aging. This was apparently due to some separation of the plies, which partially broke the asphalt seal. The exception was a duplex paper, one ply of which was a saturated felt and the other a kraft paper. This sample contained 78 lb of asphalt per 500 sq. ft, more than three times as much as any of the other laminated papers. It was impervious to water and was apparently unchanged in this respect by aging.

The single-ply papers had, in general, a relatively low initial resistance to water. In only one instance was the time required for transudation of water greater than 8 hours. However, the water resistance was retained exceptionally well after accelerated aging.

Resistance to the passage of water was determined by the dry-indicator method.[9] An indi-

[8] BS J. Research 12, 567 (1934) RP681.

[9] TAPPI Standard T433m, Tech. Assn. Pulp & Paper Ind., 122 East 42d St., New York, N. Y.

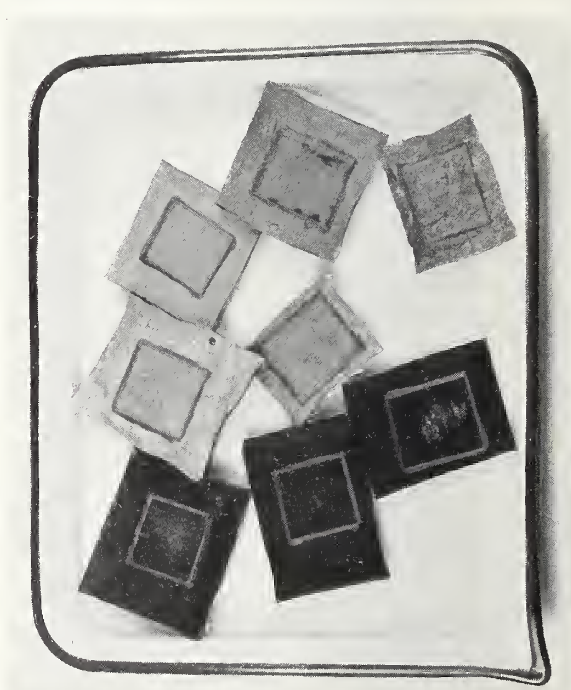

FIGURE 2.—*The dry indicator test for determining the resistance of sheathing papers to the passage of water.*

cator consisting of a mixture of eosin dye, powdered sugar, and starch is sprinkled on one surface of a 6-in. square of the paper, and a glass cover is sealed over it to prevent moisture reaching the dye except through the paper. The specimen, with edges turned up to make a boat, is then floated on water. The time of transudation of sufficient water to develop color in the indicator is a measure of the relative resistance to water penetration. Figure 2 shows the test in progress.

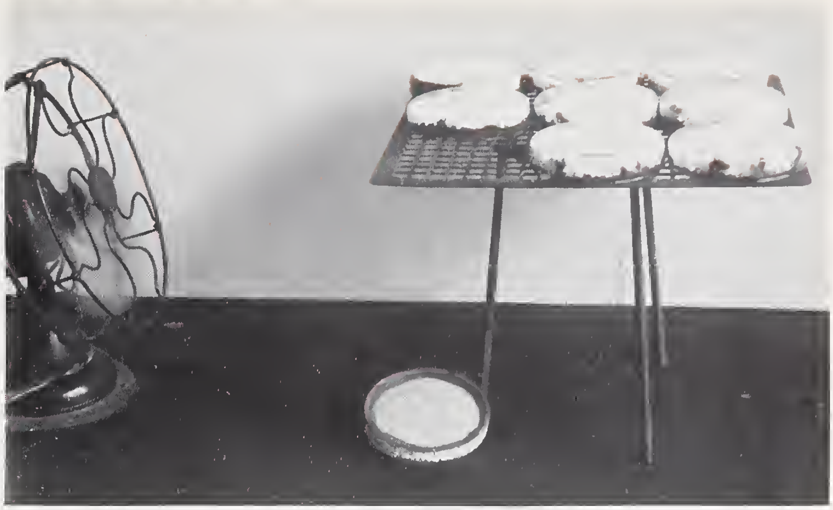

FIGURE 3.—*Testing the permeability of sheathing papers to moisture vapor.*

With the increasing application of air conditioning to house construction, the importance of a moisture seal to prevent escape of moisture from within has been stressed. The seal is important for two reasons: It aids in holding suitable humidity within the structure; and it prevents the inside moisture from penetrating through the walls to condense within them during cold weather—a condition which may become very serious in some types of construction.

In respect to permeability to water vapor the results followed roughly those for water penetration in that the papers of low permeability to water usually had correspondingly low permeability to vapor. Here again the metal-foil papers were impervious both initially and after accelerated aging. Also, paper *Z*, which was impervious to water, had the best resistance to the passage of vapor of all samples except the foil papers. All papers which showed serious increase in permeability to water vapor during aging also showed serious loss of water resistance. The last column of figures in table 1 gives the increase in permeability to water vapor as a change in magnitude rather than as a percent. Otherwise, a paper such as *ZZZ*, which after aging was a good vapor barrier, would be unfavorably compared with *W*, which had little to lose.

Measurement of permeability to water vapor was made by a method developed recently by a committee of the Technical Association of the Pulp and Paper Industry.[10] The test specimen is used as a cover for a 95-mm petri dish containing anhydrous $CaCl_2$ as a desiccant. The specimen is sealed in place with wax and the assembly is inverted and placed in a room at 65-percent relative humidity and 21° C. The assembly is weighed periodically until the rate of gain in weight is constant, and this rate is reported. Figure 3 shows this test in progress, with specimens in place on the petri dishes.

2. STRENGTH

Sheathing papers should have ample strength to stand the required handling during installation without injury. After a paper is in place in a structure, it is not subject to the sort of stresses that would cause failure, and in no instance is a paper called upon to add strength to the structure. Tensile-breaking strength measurements were made on the papers to find the comparative strength, and the loss of strength during aging was obtained as an indication of stability. It is of interest to note that large effects of accelerated aging on the strength were usually accompanied by considerable loss of resistance to water. The metal-foil papers were little affected, as might be expected, inasmuch as the strength of papers of this class is largely that of the foil. The reinforced laminated papers lost considerable strength on aging, the average loss being approximately 50

[10] G. J. Brabender, Determining water vapor permeability of sheet materials. Paper Trade J. 108, No. 4 (Jan. 26, 1939).

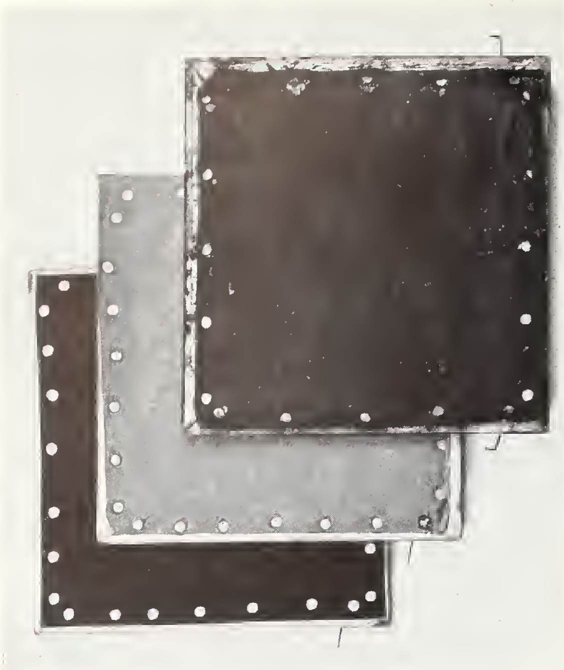

FIGURE 4.—*Shrinkage of sheathing papers after cyclic wetting and drying.*

percent. With the exception of sample *WW*, the retention of strength by the duplex papers without reinforcing cords was much better, the loss ranging from 9 to 23 percent. The single-ply papers held up well, except samples *Y* and *YY*, which had less than 10 percent of asphaltic components. The data on loss of strength appear to be of value only as an indication of the general stability of the papers, since all of the papers retained sufficient strength for purposes of utility as far as ordinary applications are concerned.

Tests of tensile strength were made on a power-driven tensile machine of the pendulum type. The test specimens were 1 in. wide and the testing length was 3 in. The speed of the loading jaw was 12 in. per minute.

3. SHRINKAGE

The usefulness of a sheathing paper as a barrier to the passage of air and moisture will be seriously impaired if, after installation, the joints should open through shrinkage. A practical test of shrinkage was made by wetting and drying specimens of the paper nailed on frames 15 in. square. After three cycles of wetting and drying most of the papers remained intact. A few, however, shrank excessively and pulled away from the nails, as shown in figure 4. The rates of shrinkage of these few papers in comparison with several which did not loosen were studied in more detail. Strips, 6- by 24-in., taken both in the machine direction and the cross direction, were immersed in water for 1 hour and allowed to dry without tension. The apparent change in length after a given number of cycles of wetting and drying are given in table 2. In this table the first five papers are those which pulled away from the nails on the frames.

TABLE 2.—*Shrinkage of sheathing papers*

Paper [a]	Shrinkage [b]					
	10 cycles		20 cycles		30 cycles	
	Machine direction	Cross direction	Machine direction	Cross direction	Machine direction	Cross direction
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
ST	1.5	4.5	2.0	5.5	4.0	6.0
SU	1.5	3.1	2.0	3.9	2.0	4.0
V	0.6	0.9	1.0	1.3	1.0	1.3
YY	.9	1.1	1.1	1.4	1.1	1.5
ZZ	.7	3.2	1.1	5.2	1.1	6.0
T	0	0	----------	----------	----------	----------
U	0	0	----------	----------	----------	----------
Q	0	0	----------	----------	----------	----------
Z	0	0	----------	----------	----------	----------

[a] Papers *ST* to *ZZ*, inclusive, shrank sufficiently in a previous test to pull away from the nails when nailed over frames 15 in. square and subsequently wet and dried. The other papers remained intact under the same test.
[b] Each cycle consisted in immersing in water 1 hr, then air-drying without tension.

IV. SUMMARY AND CONCLUSIONS

Many of the sheathing papers do not retain their resistance to the passage of water and water vapor satisfactorily under accelerated aging. This is important because, in modern house construction, the paper is depended upon as the principal barrier to the passage of vapor from within, and to a considerable degree as a barrier to the infiltration of water from without.

The laminated papers were, with one exception, relatively unstable as regards retention of water resistance. The apparent failure of these papers to retain their resistance to water and vapor may be attributed to partial separation of the plies, causing breaks in the asphaltic layer. The one paper of this type that did perform satisfactorily was a saturated felt with one ply of plain kraft paper cemented to it with asphalt.

The saturated felt was relatively heavy and carried much more asphalt than any other paper. This paper had excellent initial properties and it was practically unaffected by aging.

The results obtained on the single-ply asphalt-treated papers indicate that papers of this class should carry not less than 20 lb of asphalt per 500 sq ft for satisfactory resistance to water and vapor. The two saturated felts, *U*, and *V*, showed little change on aging; but the initial resistance was not satisfactory in the instance of *V*, which was lighter in weight and carried less asphalt.

Paper *T*, which was saturated and coated with asphalt, was quite satisfactory.

The metal-foil papers as a class were highly satisfactory with respect to the initial properties and their resistance to aging. These sheetings were impervious to both water and vapor, as determined by the available test methods, and were unaffected by the aging treatment. It should be remembered, however, that alkalies attack aluminum readily under some conditions, and that aluminum foil should never be used where wet plaster, stucco, or other masonry will come in contact with it.

The asphalt-treated asbestos sheeting did not differ essentially from saturated felt of comparable weight as regards strength and resistance to water and its vapor. The rosin-sized paper showed unsatisfactory resistance to accelerated aging.

WASHINGTON, August 15, 1939.

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